

An Abstract of the Report of the Commission Appointed to Consider the Choice of a System of Electrification for the Netherlands' Railways

By W. D. BEARCE

RAILWAY ENGINEERING DEPARTMENT, GENERAL ELECTRIC COMPANY

The attention that has been given to railroad electrification in Europe is of special importance to American manufacturers. The independent and exhaustive studies that have been made in many cases give highly valuable data. The decision in the Netherlands' report in favor of high potential direct current should be gratifying to those who were the pioneers of this system in this country.—EDITOR.

In January, 1920, the Minister of the Department of Buildings and Roads and the Board of Managers of the Netherlands' Railways appointed a commission to report on the relative desirability of the different systems available for the electrification of railroads.

The Commission consisted of the following members: Mr. L. M. Barnett Lyon, Member of the Board of Trustees for Railway Service, Chairman; J. J. W. Loenen Martinet, Chief of Electric Traction for the Netherlands' Railways, Secretary; H. Doyer, Consulting Electrical Engineer; H. J. Lessen, Chief of the Bureau of Buildings of the Netherlands' Electric Railways; Prof. I. Van Dam and G. J. Swaay, Advisors to the Government in the Inspection of Electric Current Supply.

It was particularly specified that this commission should take into consideration only such questions as concerned the relative importance of the different systems. Furthermore, the commission was to base its decision upon the gradual electrification of the entire railway system, so that the system selected was chosen with regard to the qualifications of the railway system as a whole. This point was considered of special importance because of the relatively small area covered by this country, and the confusion that would be caused by the installation of different systems.

At the time this commission was formed only two countries could be said to have officially selected a uniform system of electrification; these were Switzerland and Germany, both of which had selected single-phase alternating current. In Sweden this system was also tentatively chosen, but later, on account of the certainty of interference with communication lines, a new investigation was started of the direct-current system.

In England, France, Belgium and Italy, commissions were appointed which have made their reports since the Netherlands' commission was first appointed. The following are recommendations made by these several commissions:

England, 1500 volts direct current; France, 1500 volts direct current (with 3000 volts for some lines); Belgium, 1500 volts direct current; Italy, three-phase in North and direct current in South.

During the period from February to September, 1920, the members of the commission visited various countries, inspected the several railway systems and interviewed railway and electrical experts. Visits were made to England, Switzerland, Germany, Sweden and the United States. The question of system was studied, both from the point of view of the general electrification of railways and industries, and from the point of view of electrifying the roads alone. Naturally the first point to be settled was the question of frequency. It is pointed out that in case the railways were electrified with the single-phase system it would be necessary to provide current for this purpose at a frequency of 16 $\frac{2}{3}$ cycles. Studies were made as to the relative desirability of using steam turbines with generators of two frequencies on the same shaft or the employment of frequency changer substations for all of the railway service. It was the opinion of the commission that the double frequency generation scheme was impractical, and that the most satisfactory solution required the transmission of all current at one frequency and over the same transmission lines.

The report then proceeds to make a careful analysis of the factors entering into the choice of system in the following order:

1. Influence of stray currents on communication lines.

2. Electrical arrangement of the locomotives.
 - (a) Motor.
 - (b) Complete electrical arrangement.
3. Power and substations.
4. Overhead distribution.

INFLUENCE OF STRAY CURRENTS ON COMMUNICATION AND SIGNAL LINES

In view of the well-known difficulties caused by the disturbing influence of railway circuits on neighboring weak current conductors, an exhaustive study was made of this phase of the question. This is of particular importance because of the highly congested situation in the Netherlands, where large numbers of telephone and telegraph circuits are carried along the railroad right-of-way. In some cases as high as 100 conductors per pole are within the influence of the proposed distribution system for electric traction. The "safest and most often used solutions," namely, the relocating of these lines at a distance from the railroads, or the more expensive method of placing them in underground cables, were found to be abnormally expensive. In fact, in the Netherlands, owing to the great congestion in densely populated districts, a relocation of lines, even at a distance of 15 meters, would hardly be considered possible. Furthermore, the traffic on these lines would be so much heavier than on any existing single-phase lines that the disturbance would be even more embarrassing.

It should be noted that the conclusions of the Swedish commission were not sufficient to entirely eliminate the uncertainty with regard to possible disturbances from these sources. In fact, the funds for the electrification of the Gothberg-Stockholm line were loaned to the Government on the condition that "the cost of overcoming the disturbances in communication lines shall first be established beyond doubt as being not excessively high." The matter was thereupon given to a new commission for research.

The Netherlands' commission then cites the expedients used on the various single-phase lines concerning which data was available, including the Midi lines in France, the London, Brighton and South Coast in England, proposed electrification in Austria, Federal lines in Switzerland, Federal Railways in Germany and several American lines. The general conclusion reached was that the remedy for inductive interference from single-

phase was not only very expensive, but uncertain of accomplishing the desired results.

In this connection studies were also made of the interference of direct-current lines and the possibilities of corrosion from electrolysis. The commission was repeatedly convinced that telephoning along wires near the direct-current trolley wire takes place without any difficulty and cites tests made for the French Commission.

As regards electrolytic corrosion, the experience gained on lines in the Netherlands and the systematically applied precautions ordinarily adopted led the commission to the conclusion that less trouble will be experienced from this cause than is found in many foreign cities. In both England and the United States none of the experts whose opinions were asked foresaw any difficulties on this account.

With regard to the use of a three-phase motor, it was decided that this piece of apparatus would not be suitable for the requirements of the Netherlands' schedules. The traffic requirements, however, could be handled either by the high voltage direct-current or the single-phase motor. It is the opinion of the commission that direct current at 1500 volts is the best proposition for a combined locomotive and motor car traffic such as the Netherlands' Railways handle, because of the excessive weight of the alternating-current equipment as well as its higher cost.

Under the heading of power and substations, it is pointed out that generation of current at a frequency of 16 $\frac{2}{3}$ cycles entails the disadvantages of limitations on the turbine speed. For this frequency it is only possible to operate at 1000 r.p.m. with a limit of from 6000 to 8000 kw. per unit. With a frequency of 50 cycles, turbines can be operated at 3000 r.p.m. with capacities of 15,000 kw. and above. For this reason 50-cycle current could be generated for approximately 15 per cent less cost than the low frequency. With regard to the possibility of using geared turbines, it is stated that this type of unit is not available above 5000 kw.

Concerning the question of overhead distribution as compared with third rail, the commission concluded that the third rail is not desired in the Netherlands and, therefore, this question is not pertinent.

Comments are also made on the great value of synchronous motor-generator sets for maintaining a high power factor and therefore insuring a uniform transmission voltage.

It is also pointed out that since 1500 volts direct current has been selected by so many countries in Europe the possibility of securing equipment, at a competitive price, is much greater than with other systems.

The great desirability of uniting the load demands of the railways, industries and lighting systems was discussed as highly desirable for the purpose of securing a greater diversity of load factor.

THE INTERIM REPORT

The following points are of especial interest as outlined in the "Interim Report":

1. The three-phase has more advantages for mountainous countries, but has the disadvantage of requiring two trolley wires while the three-phase motor is less adaptable to the demands of railroad service.

2. The combination of a National Electric Supply system with distribution of power to the railroads offers more advantages with direct current than with single phase.

3. The question of overcoming the disturbances in communication lines caused by single-phase supply has not been answered satisfactorily; therefore, it cannot be decided in advance what protective measures (assuming a minimum cost) will be sufficient to insure the operation in a manner satisfactory to all reasonable requirements.

4. It was the unanimous opinion of the commission that the direct-current motor was more simple and reliable than the single-phase type, especially at moderate direct-current voltages. This opinion was strengthened by inspection of foreign roads, although the single-phase motor has been much improved in recent years.

5. The commission, therefore, is of the opinion that for the Netherlands the direct-current system must be recommended. The potential to be selected lies between 1500 and 3000 volts. So far as can be seen at present a potential of 3000 volts will not be necessary, in view of the short distances between feeding points and the weight of trains to be handled.

6. The commission, therefore, comes to the conclusion that the electrification of the Netherlands' Railways must take place by use of the direct-current system with a 1500-volt trolley potential.

FINAL REPORT

The general comparisons cited in the conclusions between the two available systems are as follows:

1. The influence on the weak current lines is of special importance in view of the limited space on the railroad, the large number of wires and the difficulty of finding another place for them in a thickly populated district.

2. The comparatively small distances between the junctions would not give the possible high tension single phase the proper advantage.

3. In connection with these short distances and the density of traffic at time of electrification, the difference in cost of construction and operation will not be very great.

4. According to the judgment of the commission the direct-current motor is better adapted to traffic than the single-phase motor.

5. The development of the automatic substations and the use of mercury rectifiers offers more probability for improvement to the entire direct-current system than to the single-phase system.

6. With the direct current a greater possibility exists in general that a considerable part of what is necessary can be manufactured in the Netherlands.

What has been quoted above in points 4, 5 and 6 may be regarded as sufficient reason for the decision reached.

The following summarizes the conclusions reached:

1. While it is uncertain whether or not a National Electric Supply system will be established, the commission believes that in any case the generating of current will have to take place at a frequency of 50 cycles.

2. If a National Electric Supply system is not established; the Holland Railways must be electrified with direct current having an operating potential of 1500 volts.

The commission is convinced that the choice of 1500 volts direct current is the proper solution for the electrification of the Netherlands' Railways. While future developments may indicate that a higher voltage could have been chosen, since a decision had to be made at the present time it could not be otherwise than 1500 volts.